On the Torque Acting on the Rotor Rotating in the Rotating Magnetic Field

3. On the Torque Acting on the Rotor Rotating in the Rotating Magnetic Field.

Syukuro Yano, Akira Katase and *Zyun Kokame.*

In the high speed rotation by rotating magnetic field [1], the torque due to the interaction between the magnetic field and the induced eddy current in the rotor was theoretically calculated from the Maxwell equations. We used a cylindrical coodinates (ρ, ϕ, z) fixed with the rotor, in which the rotating axis was chosen as the z–axis. It was assumed that the rotor was an infinitely long metal rod rotatiog with an angular velocity ω_r about its axis, in the rotating magnetic field (angular velocitp ω_m) which might be considered to be composed of two alternating components differing 90° each other in phase.

At first we must notice the relative angular velocity or slip speed ω_s and the z–component of the vector potential. The general solution of the vector potential could then be obtained easily from the well-known eddy currents equation. If we consider that this general solution might reduce to the vector potential of the external fields when ρ is greater than the radius of the rotor a, the total current density in the z–direction and the magnetic induction in the rotor can be calculated under the boundary condition at $\rho=a$.

The torque T per unit length acting on the rotor is then given as

$$T=4\mu a^2 B_0^2 f(x) \qquad \text{(in e. m. u.)}$$

$$f(x)=\frac{\mathrm{ber}_0 x\, \mathrm{ber}'_0 x+\mathrm{bei}_0 x\, \mathrm{ber}'_0 x}{x\{[(\mu+1)\mathrm{ber}_0 x-(\mu-1)\mathrm{ber}_2 x]^2+[(\mu+1)\mathrm{bei}_0 x-(\mu-1)\mathrm{bei}_2 x]^2\}}$$

where $x=\sqrt{p}\,a$, $p=\dfrac{4\pi\mu\omega_s}{\sigma}$, B_0: applied external magneticfield (r. m. s.), μ: permeability, σ: specific resistivity, $\omega_s=\omega_m-\omega_r$, and $\omega_s=2\pi f_s$. Numerical results are shown in the next table.

Table Torque T (relative value)

slip freq. f_s	0	100	150	200	500	1,000	2,000	5,000	10,000	100,000
for Duralumin	0	0.182	0.190	0.180	0.122	0.092	0.067	0.044	0.029	0.001
for Iron	0	0.090	0.104	0.108	0.076	0.050	0.031	0.021	0.013	0.004

It is seen that the torque has a maximum at 150 slip freq/sec for a Duralumin rotor, $a=1.5$ cm, $\mu=1$, $\sigma=3.4\times10^3$, and also at 200 slip freq/sec for an iron rotor, $a=0.15$cm, $\mu=100$, $\sigma=10^4$.

1) This bulletin. **18**, 92, ('49); vol. **19**, 31, ('49)